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Exploring Growth and Impact of Research Productivity for Prince of Songkla University (PSU) on Scopus Database: A Bibliometric Analysis

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Abstract

This paper presents a Bibliometric analysis of *Prince of Songkla University (PSU)* based on the Scopus database for 1978-2021. The study aimed to explore the current state, the trends, characteristics of *Prince of Songkla University (PSU),* i.e., growth of research output, collaboration trends, authorship pattern, citation patterns, contributing countries, and organizations. A total of 14,644 publications consulted of *PSU* published during the year 1978-2021 retrieved from the Scopus database, and these articles had a total of 10,257 cited items. The method used to display the research pattern and research activity on a particular topic is the bibliometric analysis commonly used recently in various research productivity. This paper employed quantitative and quantitative assessment using bibliometric analysis and visualization analysis with *Biblioshiny* for *Bibliometrix* package in *RStudio*, *MS-Excel*, and *VOSviewer* software. This study points out the development status and trends of scholarly contributions for *PSU*. These results can help the scholars get a comprehensive understanding of the knowledge structures and publishing trends. The findings will also help the research community know research identity and research impact, which might be anxiety for individual scholars and the university. The university may promote research culture, restructure the research policies with trends to enhance and enrich individuals' research performance and interdisciplinary research.

Keywords: Bibliometric Analysis, Trend Analysis, Citation Analysis, Research Productivity, Bibliometrix, Authorship Pattern

Introduction

The OECD Glossary of Statistical has defined Bibliometrics terms as *"The statistical analysis of books, articles, or other publications to measure the output of individuals/research teams, institutions, and countries, to identify national and international networks, and to map the development of multidisciplinary fields of science and technology"* (Elder, 2020), ("Bibliometrics," 2021). Bibliometrics is a type of research method used in the library and information science. It utilizes quantitative analysis and statistics to describe publication patterns within a given field or body of literature ("Bibliometrics," 2021). Bibliometrics is one of the popular techniques or metric studies that help evaluate subjects' characteristics and

citations' nature in various forms and branches of knowledge (Verma et al., 2020). Moreover, Bibliometric is a quantitative analysis method that uses mathematical and statistical tools to measure the interrelationships and impacts of publications within a given area of research ("Bibliometrics," 2021). This method can provide an overview of large amounts of academic literature and efficiently identify influential studies, authors, journals, organizations, and countries over time (Lee et al., 2020).

Bibliometric analyses have been utilized to assess research trends in various fields. (Santha kumar & Kaliyaperumal, 2015) performed scientometric analysis of mobile technology publications. (Elango, 2018) analyzed the authorship pattern and collaboration trends in Nature Nanotechnology during the first ten years. (Fuad et al., 2020) performed to measure the bibliometric profile of BioScience Trends (BST) journal. (Ardito et al., 2019) conducted bibliometric analysis, scrutinized, and classified the literature linking Big Data analytics and management phenomena. (Munik et al., 2021) examined a literature review on factors that influence the implementations and design of performance measurement systems in nonprofit organizations supported by bibliometric techniques. (Qamar & Samad, 2021) studied H.R. analytics literature by integrating bibliometric analysis and content analysis to develop a more systematic and exhaustive understanding of the research area. The study of authorship patterns of productivity is an important aspect of bibliometric analysis. Several bibliometric studies of general trends in university research have been conducted.

For example, (Patel & Bhatt, 2021) studied Sardar Patel University's research output to measure productivity and performance applied with bibliometric methods. (Badar et al., 2014) investigated whether potentially disadvantaged groups of researchers derive more research performance benefits from co-authorship network centrality. The scientometric analysis analyzes academic librarians' research productivity and scholarly impact in Tanzania for 30 years from 1984 to 2013 (Said Sife & Tandi Lwoga, 2014). (Okeji, 2019) analyzed the growth of academic librarians' research output in Nigeria, examined their research productivity, and determined the authorship pattern and collaboration degree. (S. Kumar, 2015) attempted to review the growing literature on co-authorship networks and the research gaps. (Mondal & Jana, 2018) studied the Indian LIS journals' mapping to depict India's LIS domain's authorship pattern and collaboration trend. The results recommended that LIS school consider interdepartmental collaboration to produce more quality works on emerging and innovative research areas.

Prince of Songkla University (PSU) was established in 1967 as the first university in southern Thailand to deliver graduate students, academic research, and academic services while appreciating and maintaining arts and culture. *PSU* aims to develop and deliver graduate students that empower the country and hold on to Thailand's educational, guidelines which focus on graduates equipped for the real world. As noted on the website of https://en.psu.ac.th/about-psu/introduction, the original aims of the *PSU* were to raise the general education standards and support regional industry and development. Today, *PSU* is a leading public university committed to academic excellence, reputable research, and innovation. It is one of the nine national research universities and among the top 10 comprehensive universities in Thailand by Quacquarelli Symonds' ranking. Several outstanding programs, researchers, ranking, and achievements have made *PSU* well-known and admired as a leading educational institution, not only in Thailand but across the ASEAN region. A positive reputation combined with the contributions of high-quality researchers and academics results in the academic excellence of *PSU* in many disciplines attracting students from all over the world. For example, *PSU* is ranked 4th in Thailand by *Times Higher Education World University Rankings*, the 5th in Thailand by *US NEWS and WORLD REPORT*, top ten in Thailand, and 156th in Asia *Q.S. (Quacquarelli Symonds)* Ranking. For nationally, *PSU* is ranked 3rd for Agriculture and Forestry, 4th for Life Sciences and Medicine, and 5th

Chemistry. However, in the Worldwide position, *PSU* is ranked in the top 151-200 in Agriculture (Q.S.) and top 401-500 in Medicine (Q.S.). Also, *PSU* is ranked 7th in Thailand for Research and Innovation by SCIMAGO.

A literature search using well-known databases and search engines such as the Scopus database revealed that there were at least ten bibliometric studies on research literature and its effects on various aspects on research community (Neelamma & Gavisiddappa, 2018), (Ramakrishnan & Thavamani, 2015),(Joshi, 2014),(Mondal & Jana, 2018), (Haq et al., 2021), (Patel & Bhatt, 2021), (Hadagali & Anandhalli, 2015),(Abramo & D'Angelo, 2015). However, no bibliometric research papers were published to investigate the growth and impact of scholarly contribution for *PSU* on the Scopus database. Therefore, the current study will establish the first baseline on this topic for future comparisons and for policymakers to draw plans on research culture and research performance, emphasizing research productivity. The current study used a bibliometric approach to analyze the pattern in the authorship pattern and PSU scholars' collaborative research from 1978 to 2021. Bibliometric performance analysis on *PSU* is carried out by showing any data on some crucial performance indicators, such as the number of published articles, received citations, most cited papers, the productivity on an annual basis, research productivity of institutions, author's collaboration in research work, most reputed authors, and most cited authors. They were using *Biblioshiny* from *Bibliometrix* R-package as a set of tools for quantitative research in bibliometrics (Aria & Cuccurullo, 2017) and using *VOSviewer* (van Eck & Waltman, 2020) to visualize trends in research on PSU scholars.

Assessing research activity is essential for planning future protective and adaptive policies. Thus, providing an updated insight into the research productivity of *PSU* based on the Scopus database will help the scholars to understand the most productive research institutions, highly cited papers, the frequencies and trends of published papers, and received citations and most prolific authors. This study will ultimately help university researchers and scholars select institutions or universities for education. It will assist the researchers in identifying whose research highly read.

Scope and Objective of the Study

The study's scope is confined to assessing *Prince of Songkla University (PSU)* published as research articles and indexed in the Scopus database. The publications for 44-years duration from 1978 to 2021 of *PSU* have been undertaken for this study. 6360 PSU scholars published a total of 12441 articles in 44 years duration.

The study's main objective is to analyze the publications published by *PSU* scholars for 44 years from 1978 to 2021. The specific objectives of the study are:

1. To depict the growth of research production for *PSU*
2. To estimate the authorship pattern of the publications and prolific authors
3. To identify the authors' productivity
4. To examine the author productivity and degree of collaboration among single and multiple authors
5. To identify the influence of productivity by citations received
6. To recognize the core sources for research communication

Materials and Methods

In this study, Bibliometric techniques are used as the research method. Bibliometric analysis of the literature of 14644 publications of *PSU* was performed for in-depth analysis. The search string *(AF-ID ("Prince of Songkla University" 60006314)* used and found 14644 publications affiliated with *PSU*; the search string *(DOCTYPE=" ar")* refining process limited results to a total of 12441 documents were considered for the analysis. For data retrieval and

data collection, *Bibliometrix* and *Biblioshiny*, software packages of *RStudio*, were used to connect with the Scopus API to automatically collect a list of scholars' productions. The data were processed using the *Biblioshyny* from *Bibliometrix* for the *R package*. Mapping network analysis with *VOSviewer* was used to sketch visualization graphs of citations and the studied data results.

Data Collection Methods

Scholarly research productivity of *PSU* started to be indexed in Scopus from 1978; the literature data used in this study were retrieved and extracted from the Scopus database by *Bibliometrix* functions in the *R package* on 16 February 2021. A total of 14644 documents retrieved covering the 44-year study time (1978-2021). The literature search was carried out by using keywords. The literature type was defined as "all types." Initially, 14644 documents met the selection criteria. Reducing unrelated document types of "editorial", "book chapter", "book", "note", "data paper", "review", "conference paper", "erratum", and "letter", brought the dataset down to 12441 documents as shown in Table 1. Eleven document types were found in these 14644 publications. The most frequent document type is the article (12441), with 84.84%. The second position is conference paper (1492), accounting for 11.99% of total publications. Other document types include review (400) and others (311).

Data Analysis Method

All bibliographic details related to citation information, abstract and keywords, funding details, and other information were recorded and exported in Excel file (.csv format) to perform the citation analysis and bibliographic coupling to determine the papers' trend published by researchers of *PSU*. Then, the data file was analyzed using an Excel spreadsheet[1] and *Bibliometrix* and imported into *VOSviewer* to extract a bibliographic coupling and distribute research articles into research streams with cartography analysis. *VOSviewer*, free software developed by Nees Jan van Eck and Ludo Waltman (Eck & Waltman, 2020) with powerful functions in co-occurrence analysis and co-citation analysis, was used to make visualization mapping in this paper (Table 1). Relative Growth Rate (RGR) and Doubling Time (D.T.) of *PSU* research literature have been calculated, supplementing with different growth patterns to check whether the *PSU* research literature is fit for exponential, linear, or logistic models (Hadagali & Anandhalli, 2015).

Annual Growth Rate (AGR)

The annual growth rate is calculated by using the formula by (Santha Kumar & Kaliyaperumal, 2015), as

$$\text{Annual Growth Rate (AGR)} = \frac{End\ Value - First\ Value}{First\ Value}\ x\ 100$$

where,
AGR = Publication growth in percentage
End Value = Number of publications in the present year
First Value = number of publications in the base year

Cumulative Annual Growth Rate (CAGR)

(Santha Kumar & Kaliyaperumal, 2015) stated the cumulative annual growth rate is calculated by taking the *n*th root of the total percentage growth rate, where *n* is the number of

[1] See all bibliographic details in dataset *CSV* format at https://ndownloader.figshare.com/files/26552153

years in the period being considered. This can be written the formula as follows:

$$CAGR = \left(\frac{ending\ value}{beginning\ value}\right)^{\left(\frac{1}{\#\ of\ years}\right)} - 1$$

Relative Growth Rate (RGR)

The Relative Growth Rate (RGR) is the increase in the number of articles or publications per unit of time (R. Kumar, 2016), (Santha Kumar & Kaliyaperumal, 2015). The mean Relative Growth Rate (RGR) over the interval's specific period can be calculated from the following equation (Hadagali & Anandhalli, 2015).

$$1 - 2^R = \frac{\log_e W1 \ - \ \log_e W2}{T_1 \ - \ T_2}$$

where,
$1 - 2^R$ = mean relative growth rate over the specific period of interval
$\log_e W1$ = log of the initial number of articles
$\log_e W2$ = log of the final number of articles after a specific period of interval
$T_1 \ - \ T_2$ = the unit difference between the initial time and the final time

Doubling Time (D.T.)

(Hadagali & Anandhalli, 2015) described that if the number of articles per page of a subject double during a given period, then the difference between the logarithms of numbers at the beginning and end of this period must be logarithms of number 2. If a natural logarithm is used, this difference has a value of 0.693. Thus, the corresponding doubling time for each specific period of interval and both articles and pages can be calculated by the formula (Santha Kumar & Kaliyaperumal, 2015):

$$\text{Doubling Time (D.T.)} = \frac{0.693}{R}$$

Degree of Collaboration

(Santha kumar & Kaliyaperumal, 2015) described that collaboration occurs when two or more investigators work together on a project and contribute resources and effort. The degree of collaboration varies from one discipline to another. Collaboration co-efficient is the ratio of the number of collaborative research papers during a specific period. In order to determine the degree of collaboration of publications, the number of single-authored and multi-authored publications are calculated using the formula (Santha Kumar & Kaliyaperumal, 2015):

$$\boldsymbol{C} = \frac{N_m}{N_m + N_s}$$

where,
C = degree of collaboration in a discipline
N_m = number of multiple-authored papers
N_s = number of single-authored papers

Co-Authorship Index (CAI)

To find out how co-authors' pattern has changed from 1978 to 2021, the Co-Authorship Index formula (CAI) suggested in (Mondal & Jana, 2018) has been used.

$$CAI = \frac{N_{ij}/N_{io}}{N_{oj}/N_{oo}}$$

where,

N_{ij} = number of papers having j authors in block i

N_{io} = Total output of block i

N_{oj} = number of papers having j authors for all blocks

N_{oo} = Total number of papers for all authors and all blocks

j = 1,2,3, ≥ 4

CAI = 100 implies that co-authorship in a particular block for a particular type of authorship corresponds to the world average, CAI > 100 reflects higher than average co-authorship effort, and CAI < 100 lower than average co-authorship effort in a particular block for a particular type of authorship.

Results and Discussion

Forms and Growth of Publications

Forms of Publications

Table 1 reveals that the primary source of publications covered by the Scopus database for *PSU* scholars is research articles with 12441 publications (84.96%) followed by conference papers with 1492 publications (10.19%). The review ranks the third position with 400 (2.73%), and the book chapter is in fourth place with 115 (0.78%). The remaining forms are less than one percent, as seen in the table. The results indicate that the study period's research outputs are mostly published in the research articles.

Table 1

Forms of Publications of PSU Scholars in the Scopus database

Type of Document	No. of Research Publications	Percentage
Research Article	12,441	84.96
Conference Paper	1,492	10.19
Review	400	2.73
Book Chapter	115	0.78
Letter	67	0.46
Note	46	0.31
Editorial	33	0.23
Book	3	0.02
Data Paper	4	0.03
Erratum	40	0.27
Undefined	3	0.02
Total	14,644	100.00

Growth of Publications

Table 2 and Figure 1 reveal that from 1978 to 2021, 12441 publications were published by *PSU* scholars on research articles. The highest number of publications is 1362 published in 2020. The lowest publications of 2 are published in 1978 and 1979. The average number of publications published per year was 282.75. It is seen in the table that there is an increasing trend of growth literature in the study period.

Table 2

Growth of Publications of PSU Scholars in Scopus

Year	No. of Research Publications (R.P.)	Percentage
1978	2	0.016
1979	2	0.016

1980	11	0.088
1981	4	0.032
1982	6	0.048
1983	6	0.048
1984	4	0.032
1985	6	0.048
1986	9	0.072
1987	14	0.113
1988	8	0.064
1989	15	0.121
1990	37	0.297
1991	36	0.289
1992	29	0.233
1993	49	0.394
1994	40	0.322
1995	46	0.370
1996	53	0.426
1997	80	0.643
1998	80	0.643
1999	96	0.772
2000	108	0.868
2001	109	0.876
2002	123	0.989
2003	155	1.246
2004	151	1.214
2005	226	1.817
2006	352	2.829
2007	454	3.649
2008	514	4.132
2009	447	3.593
2010	507	4.075
2011	569	4.574
2012	592	4.758
2013	664	5.337
2014	737	5.924
2015	721	5.795
2016	785	6.310
2017	890	7.154
2018	1023	8.223
2019	1105	8.882
2020	1362	10.948
2021	214	1.720

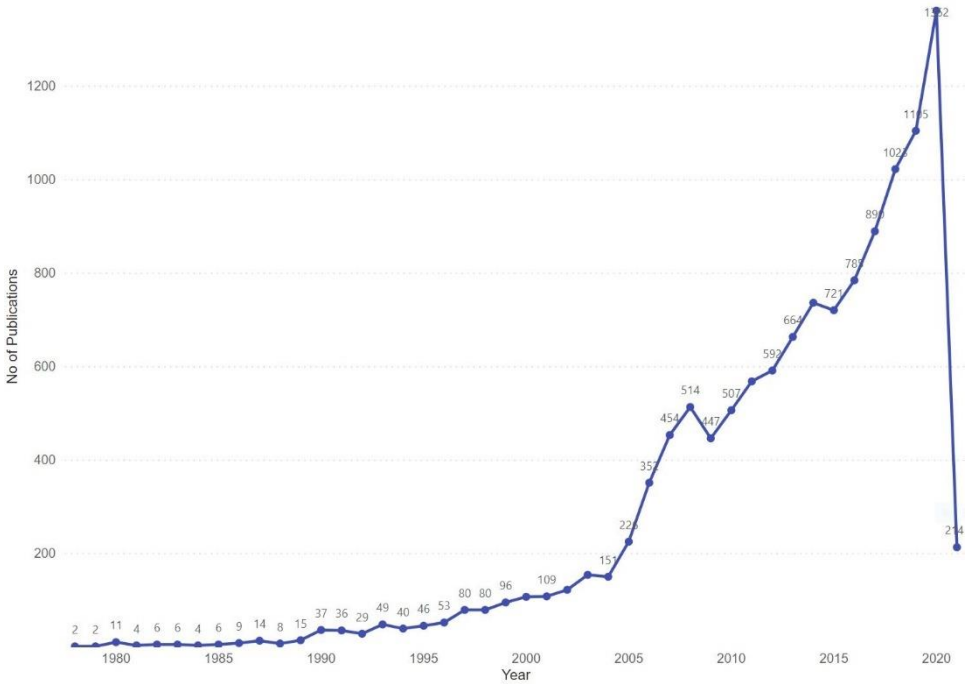

Figure 1 Growth of Publications

Annual Growth of Publications and Cumulative Growth of Publications

Table 3 provides the Annual Growth Rate (AGR) of the number of research publications for 1978-2021. Table 3 and Figure 2 show the total publications' annual growth rate calculated year-wise. Fluctuation is seen throughout the study period. The AGR for publications has an inconsistent trend from 4.50 in 1979 to 0.23 in 2020.

Table 3

Annual Growth Rate of Publications 1978-2021

Year	No. of Research Publications (R.P.)	Annual Growth Rate (AGR)	AGR Percentage (%)
1978	2	-	-
1979	2	0.00	0.00
1980	11	4.50	450.00
1981	4	-0.64	-63.64
1982	6	0.50	50.00
1983	6	0.00	0.00
1984	4	-0.33	-33.33
1985	6	0.50	50.00
1986	9	0.50	50.00
1987	14	0.56	55.56
1988	8	-0.43	-42.86
1989	15	0.88	87.50
1990	37	1.47	146.67
1991	36	-0.03	-2.70
1992	29	-0.19	-19.44
1993	49	0.69	68.97
1994	40	-0.18	-18.37
1995	46	0.15	15.00
1996	53	0.15	15.22
1997	80	0.51	50.94
1998	80	0.00	0.00
1999	96	0.20	20.00
2000	108	0.13	12.50
2001	109	0.01	0.93
2002	123	0.13	12.84
2003	155	0.26	26.02
2004	151	-0.03	-2.58
2005	226	0.50	49.67
2006	352	0.56	55.75
2007	454	0.29	28.98
2008	514	0.13	13.22
2009	447	-0.13	-13.04
2010	507	0.13	13.42
2011	569	0.12	12.23
2012	592	0.04	4.04
2013	664	0.12	12.16
2014	737	0.11	10.99
2015	721	-0.02	-2.17
2016	785	0.09	8.88
2017	890	0.13	13.38
2018	1023	0.15	14.94
2019	1105	0.08	8.02
2020	1362	0.23	23.26
2021	214	-0.84	-84.29
Total	12441	Average 57.14	Average 25.55%

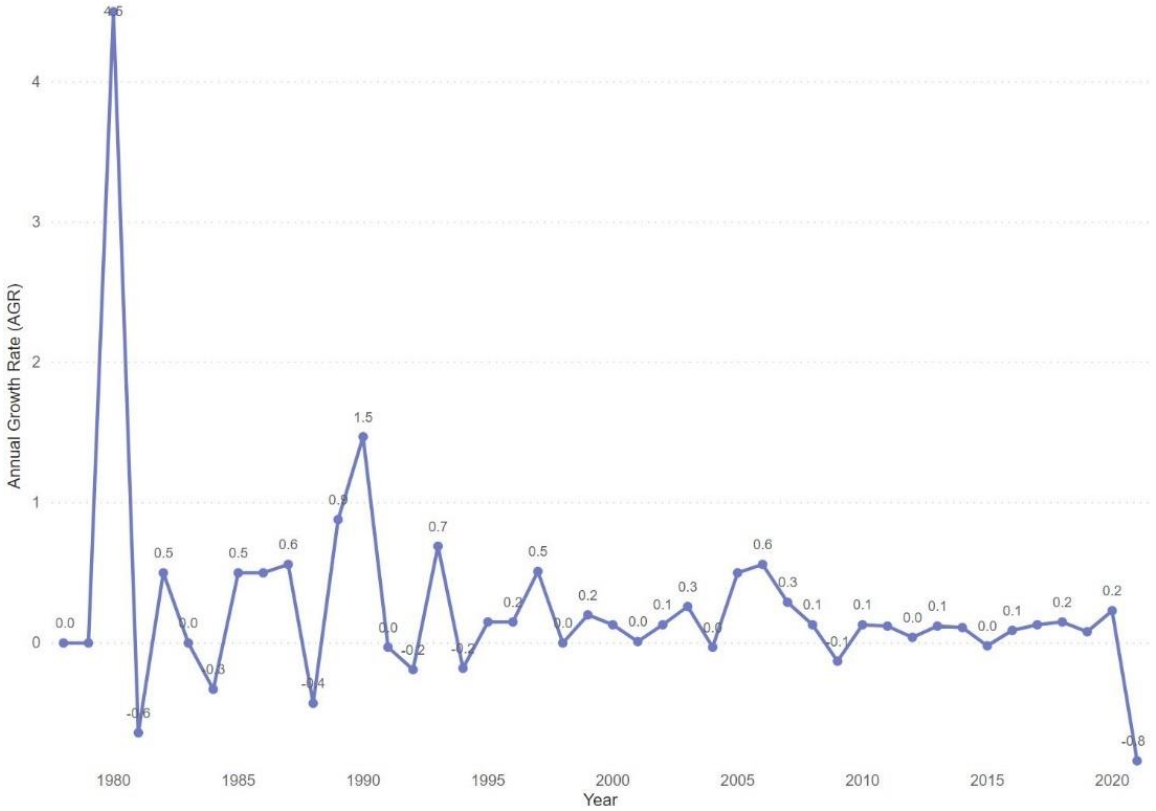

Figure 2 Annual Growth Rate of Publications

Cumulative Growth Rate of Publications

The publications' cumulative annual growth rates are fluctuated gradually from 100.00 in 1979 to 14.33 in 1992 and gradually decreased from 12.88 in 1994 to 5.36 in 2020 (Table 4 and Figure 3). This study indicates that though the yearly output is increasing year after year, the cumulative annual growth rate is downward.

Table 4

Cumulative Growth Rate of Publications 1978-2021

Year	No. of Research Publications (R.P.)	Cumulative Annual Growth Rate (CAGR)	CAGR Percentage (%)
1978	2	2	0.00
1979	2	4	100.00
1980	11	15	16.78
1981	4	19	68.10
1982	6	25	42.87
1983	6	31	38.88
1984	4	35	43.55
1985	6	41	31.59
1986	9	50	23.91
1987	14	64	18.40
1988	8	72	24.57
1989	15	87	17.33
1990	37	124	10.60
1991	36	160	12.16
1992	29	189	14.33
1993	49	238	11.11
1994	40	278	12.88
1995	46	324	12.17
1996	53	377	11.52
1997	80	457	9.61
1998	80	537	9.99
1999	96	633	9.40
2000	108	741	9.15
2001	109	850	9.34
2002	123	973	9.00

2003	155	1128	8.26
2004	151	1279	8.57
2005	226	1505	7.28
2006	352	1857	6.12
2007	454	2311	5.77
2008	514	2825	5.85
2009	447	3272	6.63
2010	507	3779	6.48
2011	569	4348	6.36
2012	592	4940	6.44
2013	664	5604	6.28
2014	737	6341	6.16
2015	721	7062	6.36
2016	785	7847	6.25
2017	890	8737	6.03
2018	1023	9760	5.80
2019	1105	10865	5.73
2020	1362	12227	5.36
2021	214	12441	9.91

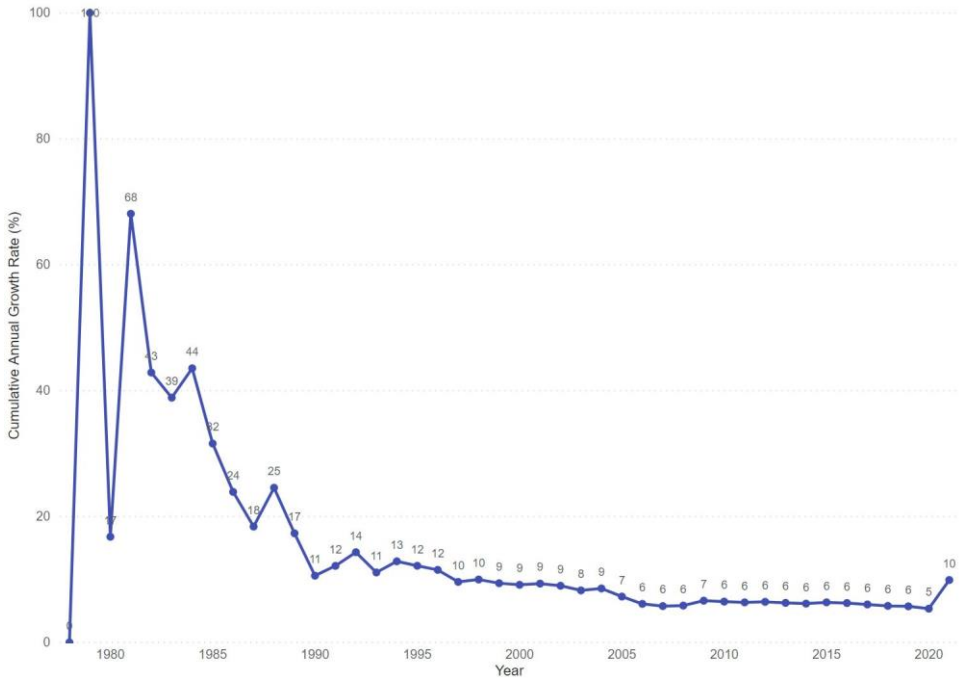

Figure 3 Cumulative Annual Growth Rate of Publications

Relative Growth Rate (RGR) and Doubling Time (D.T.)

It has been observed from Table 5 and Figure 4 that the relative growth rate (RGR) has decreased from the year 1999 (0.164) to 2002 (0.135). In 2003, it increased to 0.148, and in 2004 it decreased to 0.126. The publications' growth is not in exponential ratio. It is in an arithmetic ratio in the explosion on the PSU research publications not taking place during the study period. The doubling time (D.T.) has fluctuated around a trend when calculated year-wise. The doubling time increased from 4.226 in 1999 to 5.058 in 2001. In 2002, it slightly decreased to 4.682, and again it increased to 5.058 in 2001 (Figure 4). It increased again from 3.179 in 2007 to 6.538 in 2016. In 2017, it slightly decreased to 6.477, and again it increased to 6.477 in 2019.

Table 5
Relative Growth Rate (RGR) and Doubling Time

Year	No. of Research Publications (R.P.)	Cumulative Research Publications (CRP)	$\log_e W1$	$\log_e W2$	Relative Growth Rate (RGR)	Doubling Time (D.T.)
1978	2	2	-	0.693	-	-

1979	2	4	0.693	1.386	0.693	1.000
1980	11	15	1.386	2.708	1.322	0.524
1981	4	19	2.708	2.944	0.236	2.936
1982	6	25	2.944	3.219	0.275	2.520
1983	6	31	3.219	3.434	0.215	3.223
1984	4	35	3.434	3.555	0.116	5.974
1985	6	41	3.555	3.713	0.158	4.386
1986	9	50	3.713	3.912	0.199	3.482
1987	14	64	3.912	4.159	0.247	2.806
1988	8	72	4.159	4.277	0.118	5.873
1989	15	87	4.277	4.466	0.189	3.667
1990	37	124	4.466	4.820	0.354	1.958
1991	36	160	4.820	5.075	0.255	2.718
1992	29	189	5.075	5.241	0.166	4.175
1993	49	238	5.241	5.472	0.231	3.000
1994	40	278	5.472	5.628	0.156	4.442
1995	46	324	5.628	5.781	0.153	4.529
1996	53	377	5.781	5.932	0.151	4.589
1997	80	457	5.932	6.125	0.193	3.591
1998	80	537	6.125	6.286	0.161	4.304
1999	96	633	6.286	6.450	0.164	4.226
2000	108	741	6.450	6.608	0.158	4.386
2001	109	850	6.608	6.745	0.137	5.058
2002	123	973	6.745	6.880	0.135	5.133
2003	155	1128	6.880	7.028	0.148	4.682
2004	151	1279	7.028	7.154	0.126	5.500
2005	226	1505	7.154	7.317	0.163	4.252
2006	352	1857	7.317	7.527	0.210	3.300
2007	454	2311	7.527	7.745	0.218	3.179
2008	514	2825	7.745	7.946	0.201	3.448
2009	447	3272	7.946	8.093	0.147	4.714
2010	507	3779	8.093	8.237	0.144	4.813
2011	569	4348	8.237	8.377	0.140	4.950
2012	592	4940	8.377	8.505	0.128	5.414
2013	664	5604	8.505	8.631	0.126	5.500
2014	737	6341	8.631	8.755	0.124	5.589
2015	721	7062	8.755	8.862	0.107	6.477
2016	785	7847	8.862	8.968	0.106	6.538
2017	890	8737	8.968	9.075	0.107	6.477
2018	1023	9760	9.075	9.186	0.111	6.243
2019	1105	10865	9.186	9.293	0.107	6.477
2020	1362	12227	9.293	9.411	0.118	5.873
2021	214	12441	9.411	9.429	0.018	38.5
Total	12441	-	-	-	$\bar{x} = 0.20$	$\bar{x} = 5.01$

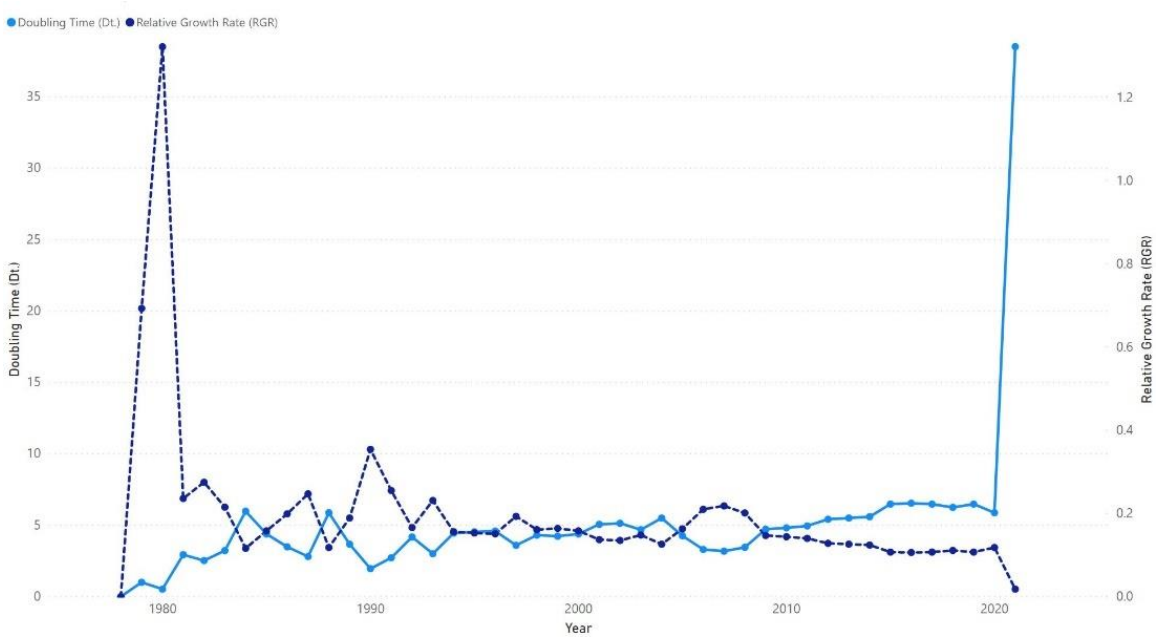

Figure 4 Relative Growth Rate (RGR) and Doubling Time (D.T.) of *PSU* literature

Authorship Pattern and Prolific Authors

In order to identify author productivity and authorship pattern, this study has attempted to analyze the following aspects: (1) extent of authorship pattern, i.e., single author, two authors, three authors, four authors, five authors, and more than five authors, (2) degree of collaboration (D.C.), and (3) pattern of co-authorship index (CAI)

Single vs. Multiple Authors

The year-wise (1978 to 2021) distribution of contributions according to the number of authors is shown in Table 5 and Figure 4. A careful examination of the data in Table 5 reveals that multiple authors than the single author contribute to PSU scholars' productivity patterns since 1978-2021. The significant percentage (96.84%). The ratio of single and multiple-authored papers was 1:31. The phenomena of research papers by multiple authorship have increased gradually since 2000. The highest incident by multiple authorship was 1301 (10.87%) in 2020.

Table 6

Single vs. Multiple Authored Papers

Year	Single Authored		Multi Authored		Total	%
	No. of Papers	Percentage	No. of Papers	Percentage		
1978	0	0.00	2	0.02	2	0.02
1979	1	0.25	1	0.01	2	0.02
1980	1	0.25	10	0.08	11	0.09
1981	0	0.00	4	0.03	4	0.03
1982	1	0.25	5	0.04	6	0.05
1983	3	0.76	3	0.02	6	0.05
1984	2	0.51	2	0.02	4	0.03
1985	1	0.25	5	0.04	6	0.05
1986	2	0.51	7	0.06	9	0.07
1987	5	1.27	9	0.07	14	0.11
1988	0	0.00	8	0.07	8	0.06
1989	4	1.02	11	0.09	15	0.12
1990	6	1.53	31	0.26	37	0.30
1991	7	1.78	29	0.24	36	0.29
1992	2	0.51	27	0.22	29	0.23
1993	5	1.27	44	0.37	49	0.39
1994	0	0.00	40	0.33	40	0.32
1995	3	0.76	43	0.36	46	0.37
1996	3	0.76	50	0.42	53	0.43
1997	6	1.53	74	0.61	80	0.64
1998	4	1.02	76	0.63	80	0.64
1999	7	1.78	89	0.74	96	0.77
2000	5	1.27	103	0.85	108	0.87
2001	5	1.27	104	0.86	109	0.88
2002	3	0.76	120	1.00	123	0.99
2003	5	1.27	150	1.25	155	1.25
2004	8	2.04	143	1.19	151	1.21
2005	7	1.78	219	1.82	226	1.82
2006	9	2.29	343	2.85	352	2.83
2007	12	3.05	442	3.67	454	3.65
2008	17	4.33	497	4.13	514	4.13
2009	16	4.07	431	3.58	447	3.59
2010	6	1.53	501	4.16	507	4.08
2011	19	4.83	550	4.57	569	4.57
2012	15	3.82	577	4.79	592	4.76
2013	31	7.89	633	5.25	664	5.34
2014	29	7.38	708	5.88	737	5.92
2015	22	5.60	699	5.80	721	5.80
2016	17	4.33	768	6.37	785	6.31
2017	20	5.09	870	7.22	890	7.15
2018	24	6.11	999	8.29	1023	8.22
2019	30	7.63	1075	8.92	1105	8.88
2020	26	6.62	1336	11.09	1362	10.95
2021	4	1.02	210	1.74	214	1.72
Total	393	100.00	12048	100.00	12441	100.00

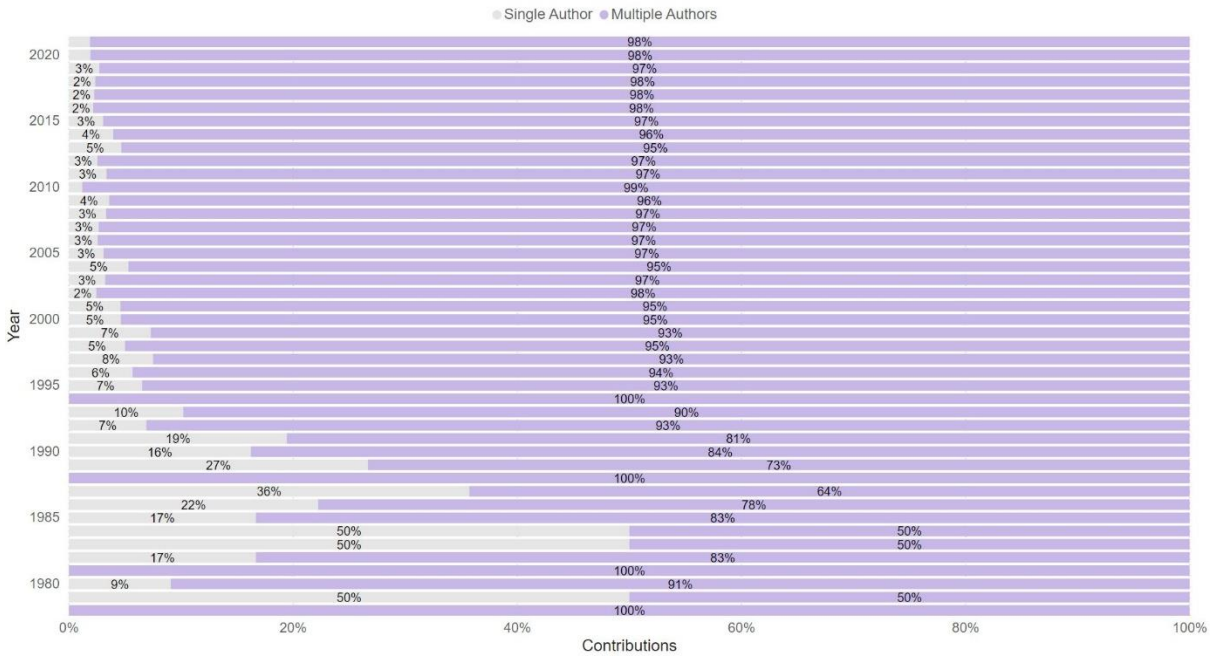

Figure 5 Single vs. Multiple Authorship

Degree of Collaboration

Authorship pattern evaluation recognized as an effective practice in the bibliometric study reflects communication patterns, productivity, and collaboration among the researchers. It has been observed from Table 7 and Figure 6, 12441 research papers are distributed in 6 patterns, i.e., single, two, three, four, five, and more than five authors in research demonstrated by 100% stacked column. 23.19% of the contributions were by three authors; 23.35% represent more than five authors. Single authorship presented at least 393 (3.16%) research work and produced more than one paper every year except 1979, 1981, 1988, 1994. The occurrence of two authorship accounted for 1838 (14.77%). The highest productivity among all patterns accounted for 2885 (23.19%) for three authorship patterns. More than five authorship observed Remarkable movement fluctuated gradually from 13 (28.26%) research of 1995 to 429 (31.49%) research for 2020. Collaborative work visible since the 12048 (96.84%) research performed by more than one author. The existence of the multiple authorship can be defined more preciously by applying the formula of Degree of Collaboration (D.C.) ratio of the number of collaborative research work (Ramakrishnan & Thavamani, 2015). The line graph in Figure 6 showed D.C. rate reinforced higher than collaborative work. DC accounted 0.95 for the years 2000, 2001, 2004, and 2013; 0.96 for the years 2009 and 2014; 0.97 for the years 2003, 2005, 2006, 2007, 2008, 2011, 2012, 2015, and 2019; 0.98 for the years 2002, 2016, 2017, 2018, 2020, and 2021; and the highest DC rate 0.99 for the year 2010. The overall D.C. rate of the study period reveals 0.97 revealed the higher presence of multiple authors in research productivity.

Table 7
Degree of Collaboration of Author Productivity

Year	Single Author	Two Authors	Three Authors	Four Authors	Five Authors	More than Five Authors	Total	More than one author	Degree of Collaboration
1978	0	0	0	1	1	0	2	2	1.0000
1979	1	0	0	0	0	1	2	1	0.5000
1980	1	6	2	0	1	1	11	10	0.9091
1981	0	3	0	1	0	0	4	4	1.0000
1982	1	2	1	0	2	0	6	5	0.8333

1983	3	3	0	0	0	0	6	3	0.5000
1984	2	0	2	0	0	0	4	2	0.5000
1985	1	1	1	1	2	0	6	5	0.8333
1986	2	4	0	1	2	0	9	7	0.7778
1987	5	6	2	1	0	0	14	9	0.6429
1988	0	3	4	0	0	1	8	8	1.0000
1989	4	1	4	2	2	2	15	11	0.7333
1990	6	7	11	8	5	0	37	31	0.8378
1991	7	7	9	6	3	4	36	29	0.8056
1992	2	8	9	3	1	6	29	27	0.9310
1993	5	9	15	10	8	2	49	44	0.8980
1994	0	13	12	4	4	7	40	40	1.0000
1995	3	12	6	10	2	13	46	43	0.9348
1996	3	13	7	10	6	14	53	50	0.9434
1997	6	13	22	13	4	22	80	74	0.9250
1998	4	9	13	19	10	25	80	76	0.9500
1999	7	18	20	26	9	16	96	89	0.9271
2000	5	23	24	11	19	26	108	103	0.9537
2001	5	22	26	16	13	27	109	104	0.9541
2002	3	16	29	25	26	24	123	120	0.9756
2003	5	17	33	28	26	46	155	150	0.9677
2004	8	17	39	36	23	28	151	143	0.9470
2005	7	36	49	51	37	46	226	219	0.9690
2006	9	47	86	78	66	66	352	343	0.9744
2007	12	56	119	144	65	58	454	442	0.9736
2008	17	71	111	128	99	88	514	497	0.9669
2009	16	66	120	93	71	81	447	431	0.9642
2010	6	69	126	118	95	93	507	501	0.9882
2011	19	85	158	126	71	110	569	550	0.9666
2012	15	83	144	158	99	93	592	577	0.9747
2013	31	87	169	164	77	136	664	633	0.9533
2014	29	124	170	181	97	136	737	708	0.9607
2015	22	124	166	164	80	165	721	699	0.9695
2016	17	110	175	179	129	175	785	768	0.9783
2017	20	104	193	206	141	226	890	870	0.9775
2018	24	165	258	183	138	255	1023	999	0.9765
2019	30	155	270	212	148	290	1105	1075	0.9729
2020	26	205	247	244	211	429	1362	1336	0.9809
2021	4	18	33	52	38	69	214	210	0.9813
Total	393	1838	2885	2713	1831	2781	12441	12048	0.9684
%	3.16	14.77	23.19	21.81	14.72	22.35	100.00	96.84	-

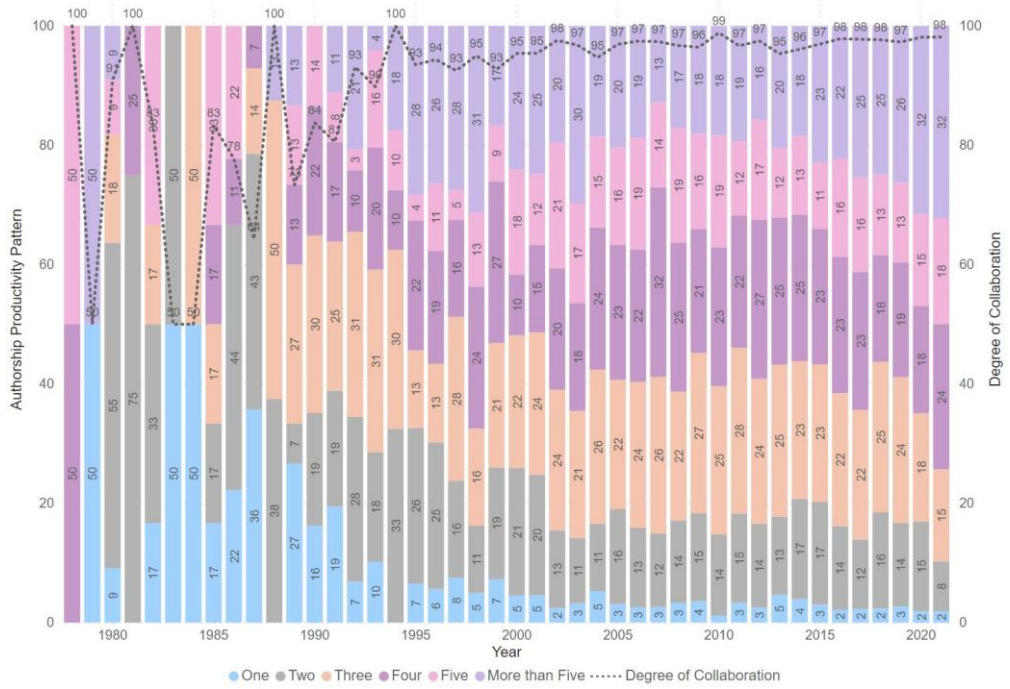

Figure 6 Year-wise Authorship Pattern and Degree Collaboration

The pattern of the Co-Authorship Index (CAI)

The Co-Authorship Index (CAI) concept proposed by (Ramakrishnan & Thavamani, 2015) examines the co-authorship pattern calculated in the current study by applying the formula to rationalize the collaborative authorship. For calculating CAI (Ramakrishnan & Thavamani, 2015), CAI = 100 specifies that the country's co-authorship effort to the world average, CAI > 100 reflects higher co-authorship effort above the average, and CAI < 100 indicates lower co-authorship effort below the average. Table 8 illustrated the co-authorship index. A decreasing trend has been seen in CAI's value for single and two authored papers from 1995 to 2020. CAI for single authorship and two authorship altered between 206.46 (1995) to 60.43 (2020) and 176.58 (1995) to 101.88 (2020), respectively. Conversely, an increasing trend has been seen in three, four, five, and more than five authored articles from 1995 to 2020. The majority highest increasing trend has been in the value of CAI for five-authored papers. Remarkably the CAI for five authorship increases progressively from 29.54 for 1995 to 105.26 for 2020. This study indicates that five-authored papers are increasing year by year in *PSU* scholars' publications. (Patel & Bhatt, 2021) suggested that constructive higher co-authorship effort above the average and sustenance innovative practice of the research occurrences in collaborative manners.

Table 8

Co-Authorship Index (CAI)

Year	One Author		Two Authors		Three Authors		Four Authors		Five Authors		> Five Authors		TRP
	RP	CAI	RP	CAI	RP	CAI	RP	CAI	RP	CAI	RP	CAI	
1978	0	0.00	0	0.00	0	0.00	1	229.28	1	339.73	0	0.00	2
1979	1	1582.82	0	0.00	0	0.00	0	0.00	0	0.00	1	223.68	2
1980	1	287.79	6	369.21	2	78.41	0	0.00	1	61.77	1	40.67	11
1981	0	0.00	3	507.66	0	0.00	1	114.64	0	0.00	0	0.00	4
1982	1	527.61	2	225.63	1	71.87	0	0.00	2	226.49	0	0.00	6
1983	3	1582.82	3	338.44	0	0.00	0	0.00	0	0.00	0	0.00	6
1984	2	1582.82	0	0.00	2	215.62	0	0.00	0	0.00	0	0.00	4
1985	1	527.61	1	112.81	1	71.87	1	76.43	2	226.49	0	0.00	6
1986	2	703.48	4	300.83	0	0.00	1	50.95	2	150.99	0	0.00	9
1987	5	1130.59	6	290.09	2	61.60	1	32.75	0	0.00	0	0.00	14
1988	0	0.00	3	253.83	4	215.62	0	0.00	0	0.00	1	55.92	8
1989	4	844.17	1	45.13	4	114.99	2	61.14	2	90.60	2	59.65	15
1990	6	513.35	7	128.06	11	128.20	8	99.15	5	91.82	0	0.00	37
1991	7	615.54	7	131.61	9	107.81	6	76.43	3	56.62	4	49.71	36
1992	2	218.32	8	186.72	9	133.83	3	47.44	1	23.43	6	92.56	29
1993	5	323.03	9	124.32	15	132.01	10	93.59	8	110.93	2	18.26	49
1994	0	0.00	13	219.99	12	129.37	4	45.86	4	67.95	7	78.29	40
1995	3	206.46	12	176.58	6	56.25	10	99.69	2	29.54	13	126.43	46
1996	3	179.19	13	166.03	7	56.95	10	86.52	6	76.92	14	118.17	53
1997	6	237.42	13	109.99	22	118.59	13	74.52	4	33.97	22	123.02	80
1998	4	158.28	9	76.15	13	70.07	19	108.91	10	84.93	25	139.80	80
1999	7	230.83	18	126.91	20	89.84	26	124.20	9	63.70	16	74.56	96
2000	5	146.56	23	144.15	24	95.83	11	46.71	19	119.54	26	107.70	108
2001	5	145.21	22	136.62	26	102.86	16	67.31	13	81.04	27	110.81	109
2002	3	77.21	16	88.05	29	101.67	25	93.21	26	143.63	24	87.29	123
2003	5	102.12	17	74.24	33	91.81	28	82.84	26	113.97	46	132.76	155
2004	8	167.72	17	76.20	39	111.38	36	109.33	23	103.49	28	82.95	151
2005	7	98.05	36	107.82	49	93.50	51	103.48	37	111.24	46	91.05	226
2006	9	80.94	47	90.38	86	105.36	78	101.61	66	127.40	66	83.88	352
2007	12	83.67	56	83.49	119	113.03	144	145.45	65	97.28	58	57.15	454
2008	17	104.70	71	93.50	111	93.13	128	114.20	99	130.87	88	76.59	514
2009	16	113.31	66	99.94	120	115.77	93	95.41	71	107.92	81	81.06	447
2010	6	37.46	69	92.12	126	107.17	118	106.73	95	127.32	93	82.06	507
2011	19	105.71	85	101.12	158	119.74	126	101.55	71	84.78	110	86.48	569
2012	15	80.21	83	94.90	144	104.89	158	122.39	99	113.63	93	70.28	592
2013	31	147.79	87	88.69	169	109.76	164	113.26	77	78.79	136	91.63	664
2014	29	124.56	124	113.88	170	99.47	181	112.62	97	89.43	136	82.55	737
2015	22	96.59	124	116.41	166	99.28	164	104.31	80	75.39	165	102.38	721
2016	17	68.56	110	94.85	175	96.13	179	104.57	129	111.66	175	99.73	785
2017	20	71.14	104	79.10	193	93.51	206	106.14	141	107.65	226	113.60	890
2018	24	74.27	165	109.17	258	108.76	183	82.03	138	91.66	255	111.51	1023
2019	30	85.95	155	94.95	270	105.37	212	87.98	148	91.01	290	117.41	1105
2020	26	60.43	205	101.88	247	78.20	244	82.15	211	105.26	429	140.91	1362
2021	4	59.17	18	56.93	33	66.50	52	111.43	38	120.65	69	144.24	214
Total	393	100.00	1838	100.00	2885	100.00	2713	100.00	1831	100.00	2781	100.00	12441

Note: RP = Research Papers; **TRP** = Total Research Papers

Citation Influence of Research Publications

Citation analysis is the major tool of Bibliometric study. Several studies evaluated citations as is the instrument to measure scholars' productivity (Patel & Bhatt, 2021); (Santha Kumar & Kaliyaperumal, 2015); (Elango, 2018); (Zupic & Čater, 2015); (Hadagali & Anandhalli, 2015); (Abramo & D'Angelo, 2015). Table 9 quantifies the influence of citation for PSU research published between 1978 and 2021. The 12441 research received 10257 citations with an average of 0.82 citations per article. The most citations 828 (8.07%) received by 1023 (8.22%) publications of the year 2018 followed by the year 2017, received 783 (7.63%) for 890 (7.15%) publications. Citation analysis indicates that the increasing trend rises from 2 (0.02%) to 505 (4.92%); however, publication's life should be a major reason for this variation. The overall mean RGR(C) and D.T. (C) calculated 0.19 and 12.68 for 1978 to 2021.

Table 9

Research Publications by Citation Received

Year	No. of Research Publications	Citation Received (C.R.)	Cumulative Citation Received (CCR)	$\log_e C1$	$\log_e C2$	Relative Growth Rate Citations RGR(C)	Doubling Time Citations D.T. (C)
1978	2	2	2	-	0.6931	-	-
1979	2	2	4	0.6931	1.3863	0.6932	1.000
1980	11	11	15	1.3863	2.7081	1.3218	0.524
1981	4	4	19	2.7081	2.9444	0.2363	2.932
1982	6	5	24	2.9444	3.1781	0.2337	2.966
1983	6	4	28	3.1781	3.3322	0.1541	4.497
1984	4	2	30	3.3322	3.4012	0.0690	10.044
1985	6	6	36	3.4012	3.5835	0.1823	3.801
1986	9	7	43	3.5835	3.7612	0.1777	3.900
1987	14	12	55	3.7612	4.0073	0.2461	2.816
1988	8	7	62	4.0073	4.1271	0.1198	5.783
1989	15	13	75	4.1271	4.3175	0.1904	3.640
1990	37	30	105	4.3175	4.6540	0.3365	2.060
1991	36	32	137	4.6540	4.9200	0.2660	2.605
1992	29	24	161	4.9200	5.0814	0.1614	4.294
1993	49	43	204	5.0814	5.3181	0.2367	2.928
1994	40	39	243	5.3181	5.4931	0.1750	3.961
1995	46	44	287	5.4931	5.6595	0.1664	4.165
1996	53	53	340	5.6595	5.8289	0.1694	4.090
1997	80	76	416	5.8289	6.0307	0.2018	3.434
1998	80	76	492	6.0307	6.1985	0.1678	4.130
1999	96	91	583	6.1985	6.3682	0.1697	4.084
2000	108	104	687	6.3682	6.5323	0.1641	4.222
2001	109	105	792	6.5323	6.6746	0.1423	4.871
2002	123	120	912	6.6746	6.8156	0.1410	4.914
2003	155	150	1062	6.8156	6.9679	0.1523	4.550
2004	151	150	1212	6.9679	7.1000	0.1321	5.245
2005	226	219	1431	7.1000	7.2661	0.1661	4.171
2006	352	341	1772	7.2661	7.4799	0.2138	3.242
2007	454	384	2156	7.4799	7.6760	0.1961	3.534
2008	514	491	2647	7.6760	7.8812	0.2052	3.377
2009	447	427	3074	7.8812	8.0307	0.1495	4.634
2010	507	487	3561	8.0307	8.1778	0.1471	4.711
2011	569	544	4105	8.1778	8.3200	0.1422	4.875
2012	592	559	4664	8.3200	8.4476	0.1276	5.430
2013	664	621	5285	8.4476	8.5726	0.1250	5.543
2014	737	688	5973	8.5726	8.6950	0.1224	5.662
2015	721	658	6631	8.6950	8.7995	0.1045	6.631
2016	785	709	7340	8.7995	8.9011	0.1016	6.821
2017	890	783	8123	8.9011	9.0025	0.1014	6.837
2018	1023	828	8951	9.0025	9.0995	0.0970	7.143
2019	1105	781	9732	9.0995	9.1832	0.0837	8.282
2020	1362	505	10237	9.1832	9.2338	0.0506	13.705
2021	214	20	10257	9.2338	9.2357	0.0019	361.752
Total	**12441**	**10257**	**-**	**-**	**-**	$\bar{x}$ **= 0.19**	$\bar{x}$ **=12.68**

Most Productive Authors

The analysis of Table 10 and Figure 7 show that 6360 unique authors contributed to the 12441 articles. The study revealed that "*Benjakul, S.*" and "*Chantrapromma, S.*" ranked the first and second with the contribution of 781 papers, 501 papers, followed by "*Fun, H.K.*" has the third highest with contributions research output of 488 papers. It could be found from this analysis, "*Benjakul, S.*," "*Chantrapromma, S.*," "*Fun, H.K.*" were identified as the most prolific authors among the top ten authors. Figure 7 also shows author-level indexes with respective total citations. H-index is an author-level index defined as the number of articles *h* that each article receives at least *h* citations (Maddisetty & Babu, 2020). It revealed that *Benjakul, S.* (81), followed by *Visessanguan, W.* (57), and *Fun, H.K.* (55), has prominent *h*-index among the top ten authors. In the observation of the *h*-index suggested by (Patel & Bhatt, 2021) measures the productivity as well impact of research published by authors diversify the ranking of top authors and the top rank captured by "*Benjakul, S.*" with 81 *h*-index followed by "*Visessanguan, W.*" with 57 of *h*-index. The ranked author "*Chantrapromma, S.*" in counts for numbers of research publication downgraded on the 9th rank with a rate of 26 *h*-index.

Table 10
Top Ten Productive Authors

Rank	Author Name	No. of Papers	Citations	*h*-index
1	Benjakul, S.	781	26569	81
2	Chantrapromma, S.	501	3929	26
3	Fun, H.K.	488	20145	55
4	Chongsuvivatwong, V.	283	5081	34
5	Phuruangrat, A.	204	4009	34
6	Visessanguan, W.	201	10662	57
7	Thongtem, S.	181	6252	40
8	Thongtem, T.	181	5634	39
9	Kanatharana, P.	179	3623	36
10	Phongpaichit, S.	169	4367	38

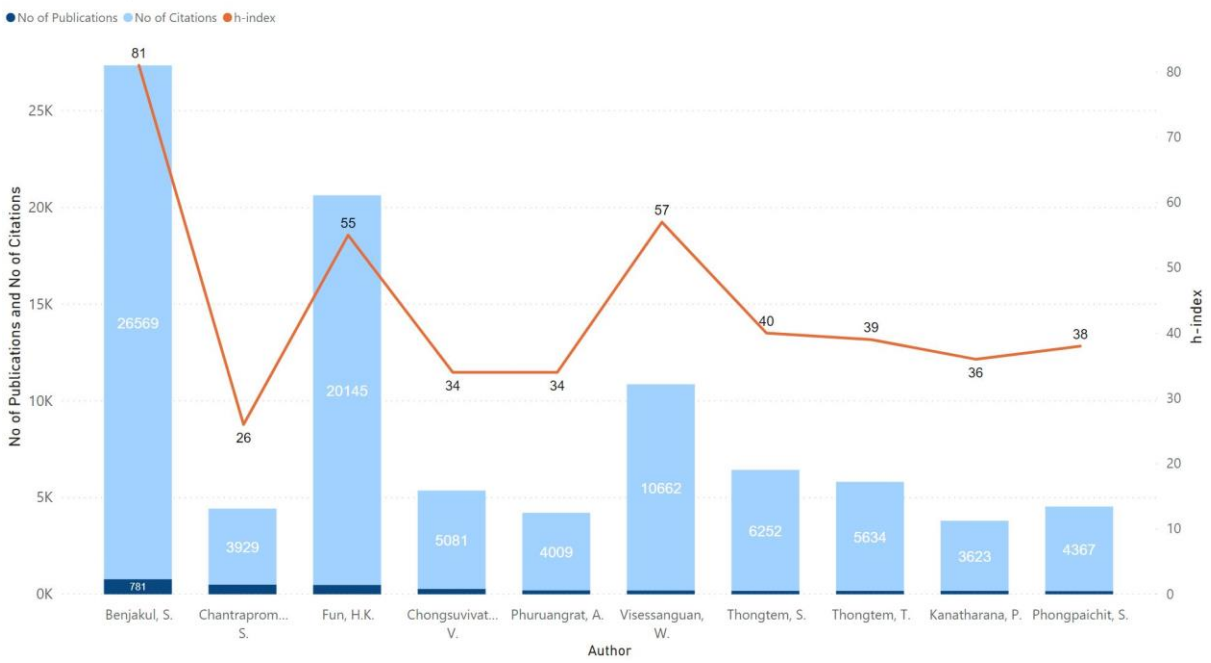

Figure 7 The Most Productive Authors (Top 10)

Mapping Author Collaboration

Figure 8 shows the author "*Benjakul, S.*" has the highest rank in research collaboration

regarding publication (781), most cited author (26569), and total link strength (1271). The authors "*Chantrapromma, S.*" (501), "*Fun, H.K.*" (488), and "*Chongsuvivat, V.*" (283) have publication collaboration with 3929, 20145, 508 citations, respectively.

(a) (b)

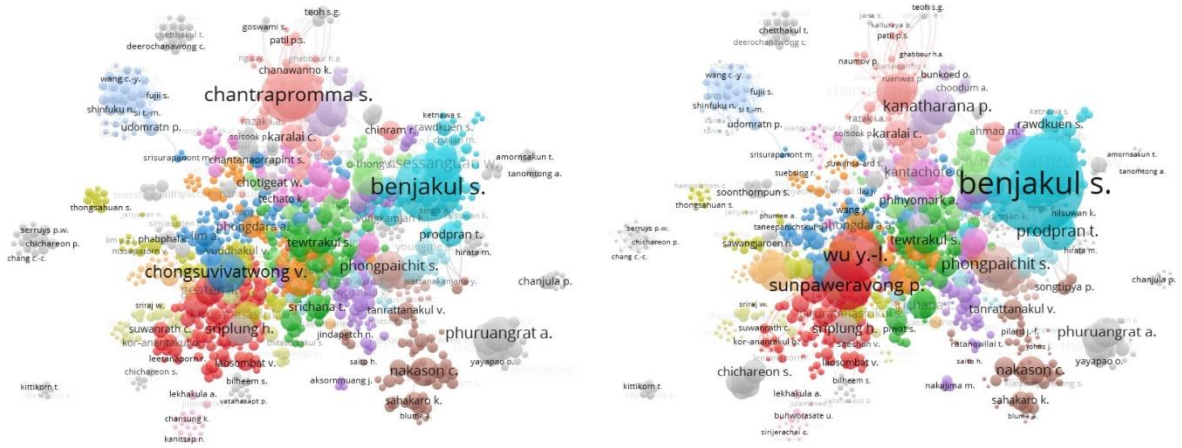

Figure 8 (a) Author Collaboration (Publications), *(b)* Author Collaboration (Citations)

Mapping Author Keywords Occurrences

Figure 9 visualized the network map of the author's keywords' popularity with the threshold of 6 frequently used keywords. As depicted in Figure 9, the author's keyword "*Thailand*" has ranked first (473) times occurrences with 508 total link strength, while the word "*Natural Rubber*" ranked second (171) times of occurrences with 279 total link strength. The words "*Antioxidant*," "*Gelatin*," and "*Surimi*" have times of occurrences with 126, 77, and 54 total link strength, respectively.

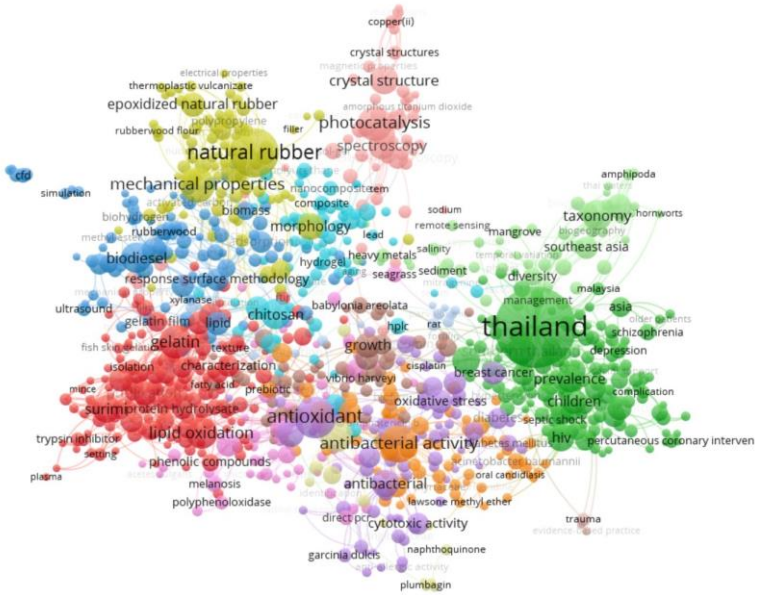

Figure 9 Co-occurrence Network Map of the Popularity of Author's Keywords

Most Preferred Publication Source

Table 11 presented ranked according to the numbers of research published. "*Songklanakarin Journal of Science and Technology*" ranked on top with 548 (4.40%) publications, followed by "*Journal of the Medical Association of Thailand*" and "*Acta*

Crystallographica Section E Structure Reports Online" with 501, 431 publications, respectively. However, the significant gap visible in the top three positions. The data in Table 12 revealed all the top ten productive subject area related to "*Applied Science or Pure Science*" discipline, i.e., "*Medicine,*" "*Agricultural and Biological Sciences*," "*Engineering*," "*Chemistry*," "*Biochemistry, Genetics, and Molecular Biology*," "*Pharmacology, Toxicology and Pharmaceutics*" absence of "Humanities or *Social Science*" discipline. This study suggests that the university procures core publications or sources" and makes them available for access to the research community.

Table 11
Most Productive Journals (Top 10)

Rank	Journal Titles	No. of Papers	Percentage
1	Songklanakarin Journal of Science and Technology	548	4.40
2	Journal of the Medical Association of Thailand	501	4.03
3	Acta Crystallographica Section E Structure Reports Online	431	3.46
4	Food Chemistry	168	1.35
5	Southeast Asian Journal of Tropical Medicine and Public Health	123	0.99
6	International Food Research Journal	109	0.88
7	Journal of Applied Polymer Science	93	0.75
8	Plos One	78	0.63
9	Scienceasia	76	0.61
10	Walailak Journal of Science and Technology	75	0.60

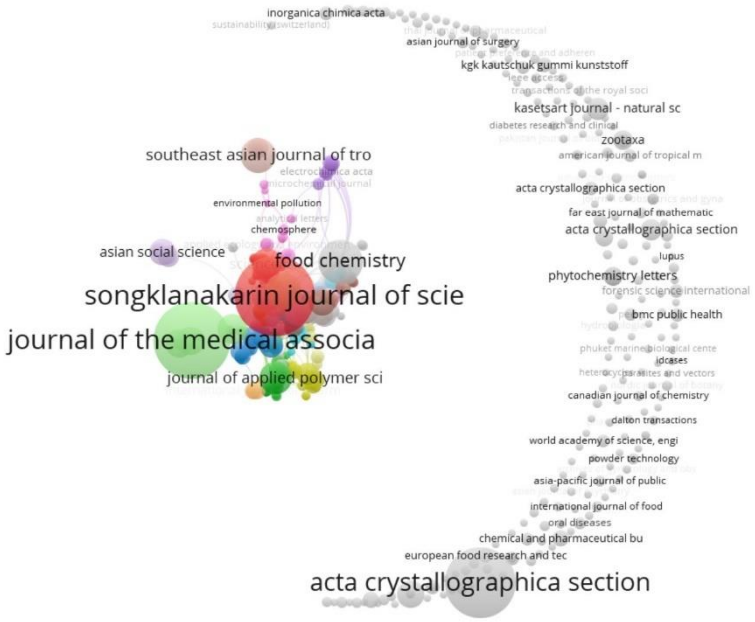

Figure 10 Publication by Source Impact

Table 12
Subject Distribution (Top 10)

Rank	Subject Area	No. of Papers
1	Medicine	3462
2	Agricultural and Biological Sciences	2778
3	Chemistry	2224
4	Biochemistry, Genetics and Molecular Biology	2036
5	Materials Science	1747
6	Engineering	1144
7	Physics and Astronomy	1090
8	Pharmacology, Toxicology, and Pharmaceutics	942
9	Multidisciplinary	895
10	Chemical Engineering	844

Conclusion

The study findings revealed the inconsistent growth in research productivity by *PSU* scholars. This study contributes to understanding PSU scholars' research publications through trend analysis, bibliometric analysis, and map and knowledge structure analysis. This study aims to analyze the number of contributions made by the researchers of *Prince of Songkla University (PSU)* published on the Scopus database during 1978-2021. The analysis showed that PSU scholars published 12441 publications. The paper has observed a rapid growth in the number of publications in the field under study and, in recent years, has produced a good number of publications compared to older days. The single most prevalent form of publication is the research articles, in which 84.96% of the total literature is published. This study shows that the *PSU* researcher's preferred medium of communication is research articles.

The study findings revealed the inconsistent growth in publication productivity, and citation received. The mean relative growth rate of publication (0.20) and mean doubling time (5.01) not much stunning and required significant attention. Positive output revealed in the doubling time of authorship pattern (0.97) the higher presence of multiple authors in research productivity. According to the prolific authors' analysis, the results show that the most prolific authors are Benjakul, S. (*h*-index 81) with 781 published papers with 26569 citations. A more detailed analysis of the author's keyword shows that "*Thailand*" has ranked first times occurrences, followed by "*Natural Rubber*," "*Antioxidant*," "*Gelatin*," and "*Surimi*.". This study suggests that natural science or health science keywords have played an influential and central role in the network.

The numbers of research published, the significant gap visible in the top three positions, i.e., "*Songklanakarin Journal of Science and Technology*" ranked on top publications, followed "*Journal of the Medical Association of Thailand*" and "*Acta Crystallographica Section E Structure Reports Online*." Core sources of publication identified favored the most of PSU scholars for "*Research Articles*," identified core journals related to "*Medical Science or Pure Science*" but not in "*Humanities or Social Sciences*" discipline.

The bibliometric analysis and trend analysis of scholarly contributions for PSU will help the research community know the core sources of publication, research identity, and research impact, which should be anxiety for *PSU* and individual scholars. The university should make more effort to promote research culture, develop a professional research environment, and restructure the research policies with contemporary trends to enhance and enrich individuals' research performance and additional attention on interdisciplinary research and humanities and social sciences discipline.

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Author Contributions

Pachisa Kulkanjanapiban: Collected the data, Contributed data or analysis tools (*MS-Excel, VOSviewer*), Perform the analysis, Wrote the paper, Other contributions.

Tipawan Silwattananusarn: Conceived and designed the analysis, Contributed data or analysis tools (*Bibliometrix* in *RStudio*), Perform the analysis, Wrote the paper, Other contributions.

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